in a basin of water, and the circuit completed through a galvanometer. The temperature of the water in the basin might then be altered till the galvanometer gave zero indication."

Sir Wm. Thomson now adds the recommendation that, in carrying out this method, the two wires, each well covered with gutta-percha, should be twisted together; that the wires should be stout and as homogeneous as possible throughout, and that a piece of stout copper tube should be attached to the lower junction, this tube being uncovered and in close contact with the earth all round, its purpose being to insure that the junction takes the proper temperature.

It would probably be desirable, in filling up the bore, to mix clay with the original material to render it watertight, for it would be impossible to render the filling of the bore as compact as the surrounding rock.

Several pairs of wires would be buried in the same bore, with their lower junctions at different carefully-measured depths.

The upper junctions would be kept in a room provided with a steady table for a mirror-galvanometer.

THE RAINFALL OF THE WORLD[1]

1. THE pamphlet referred to below embodies the outline of an attempt to bring into harmony the disconnected, and in some cases apparently irreconcilable results that have hitherto attended comparisons of terrestrial rainfall and sun-spot variations. It relates, therefore, to the entire rainfall system of the globe.

2. The plan by which it is thought this object will be best attained is one which divides the world into a number of rainfall zones where either *à priori* considerations or actual experience would lead us to expect typical changes in the effects of a recurring secular variation in solar radiated heat upon the rainfall; it being immaterial as far as regards the practical advantages secured by this method of hyeto-graphical subdivision, whether the solar radiation be ultimately found to vary directly or inversely with the sun-spots.

3. The way in which typical changes may arise in different parts of the earth from the effects of an assumed recurring secular change in solar radiated heat, is shown by a reference to the general scheme of atmospheric circulation in conjunction with the two leading factors of variability, viz., season and latitude.

4. A consideration of these points leads the author to divide the world into five zones, which either theoretically might, or are actually known to, involve some typical change in the secular variation of the rainfall either of one season or the whole year.

5. Partly to illustrate this mode of subdivision by applying a reasonable working hypothesis, and partly in the absence of absolutely conclusive evidence in its favour, by exhibiting the harmony of existing facts with the conditions theoretically deduced from it, to promote its ultimate adoption, the theory of the inverse variation of solar radiated heat with the sun-spots is assumed throughout.

6. It is also shown in the Introduction that we have a good deal of evidence in favour of the same theory, both *à priori*, from a consideration of the principle of conservation of energy as applied to the sun, as well as indirect, from the results of thermometrical observations.

7. In applying this hypothesis to determine the rainfall variation, account is mainly taken of the direct relation between wind velocity and temperature, the secular changes in solar radiation being assumed to cause *similar* effective secular changes in the velocity of the larger atmospheric convection currents.

8. An induction from Messrs. Blanford and Eliot's theory of cyclone-generation is then made use of, in combination with the preceding hypothesis, from which it appears that while, owing to the diminished solar temperature, evaporation might be lessened in the tropics at the epoch of maximum sun-spot, the diminished carrying power of the wind (by which the prevalence of cyclones at this epoch would be accounted for, according to Blanford and Eliot's theory) might allow of greater precipitation near the place of evaporation, and therefore of a generally heavier rainfall in these regions. At the opposite epoch, on the other hand, the increased velocity of the wind would probably cause a wider distribution of tropical vapour, and therefore in combination with the direct effects of the assumed increase in solar radiation at the same epoch give rise to a deficiency of rain in parts, more especially those in which the local conditions normally tend to produce aridity.

9. These hypothetical results are then shown to approximately agree with the actual results of observations recorded in these regions.

10. It is next shown that the effects of the assumed secular change in the velocity of the anti-trade (the prevailing wind of the temperate zone) should differ considerably from those in the case of the monsoons and trades of the tropics, an increased velocity in the case of the anti-trade causing a greater quantity of tropical vapour to be conveyed to the temperate regions, and consequently a greater degree of humidity to ensue there. When, therefore, the direct effects of the assumed increase of solar heat at such an epoch are at a minimum, that is to say, in the *winter*, the relative humidity, and consequently the rainfall, should be *increased*. It is also evident that such an effect should be most conspicuously felt in those regions where rain falls *only* in the winter, and is due to the descent of the anti-trade.

11. The occurrence of this inverse variation in the zone of winter rains, which in the case of the Mediterranean stations (*Zeitschrift für Meteorologie*, Band viii. No. 6), had hitherto been deemed unfavourable to Messrs. Lockyer and Meldrum's generalisation regarding the direct variation of terrestrial rainfall with the sun-spots, is also shown to be visible in the winter rainfall of Northern India, and the rainfalls of Jerusalem and California, thereby affording some preliminary support to the notion that it holds over a still wider extent of the globe where the rain falls mostly during the winter.

12. The attempt is then made to show that while the direct effects of the secular change in the sun's heat over extra-tropical continents may, during the summer, operate so far as to destroy the indirect effects produced by the corresponding variations in the strength of the anti-trade, and as Dr. Hahn has shown in the case of the summer rainfalls of several stations in Central Europe, actually cause a *direct* variation with the sun-spots, there are, as there should be, in accordance with the hypothesis, some preliminary indications of an *inverse* variation of that proportion of the total which falls during the winter months alone, even in those places where the rain falls throughout the year. This fact, then, would imply that a change of season causes a change of type in the character of the variation, so that in order to render the variations distinctly apparent we should compare the winter and summer falls separately. It may also be inferred that the quality of the variation in the total annual fall will depend on the preponderance of the summer or winter falls respectively, which fact may help to account for the numerous anomalies noticed by those who have hitherto compared the total annual falls of places in the temperate zone with sun-spots.

13. It is finally inferred in the appendix, as a direct result of the hypothesis assumed throughout, that the winter gales of the temperate zone and the cyclones of the tropics should bear a complementary relation to each other, the former being most frequent about the time of minimum, and the latter about that of maximum, sun-spot. Some evidence in favour of this notion was recently communicated to NATURE by Mr. S. A. Hill (vol. xviii. p. 616).

14. The pamphlet is intended by the author to be considered as merely tentative, and not by any means conclusive. It is the method of division into zones and the separate comparison of seasonal falls, rather than the accordance of data with theoretical deductions, to which he desires to give prominence, and which he thinks may be of some assistance to other workers in the same field.

[1] The Rainfall of the World in Connection with the Eleven-Year Period of Sun-spots. With an Introduction and Appendix. By E. D. Archibald, Professor of Mathematics in the Patna College. (Calcutta and London: Thacker and Co. 1878.)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

THE Cambridge Mathematical Tripos list was published on the 24th. This year the list contains 91 names. There are 28 classed as Wranglers, 33 as Senior Optimes, 29 as Junior Optimes, and 1 Ægrotat. In 1878 the list contained 94 names, 31 being Wranglers, 30 Senior Optimes, 29 Junior Optimes, and 4 Ægrotant. The first three Wranglers are Mr. A. J. Campbell Allen, of St. Peter's, Mr. George Walker, of Queen's, and Mr. Carl Pearson, King's. Mr. Campbell Allen, of St. Peter's College, the Senior Wrangler, is a native of Belfast, and was born in 1856. He received his elementary education at the

Royal Academical Institution, Belfast. In 1872 he became a student at Queen's College, Belfast, where he succeeded in winning several scholarships and also two Peel Exhibitions, one for general proficiency and the second for mathematics. In 1875 he was elected to an open scholarship at St. Peter's, and in October of that year he graduated B.A. at the Queen's University, subsequently proceeding M.A. On each occasion he obtained a first-class for mathematical science, and was awarded a gold medal. He has won several college prizes during his residence at Cambridge. Mr. Walker is a native of Durham, and was educated at Durham University, of which he is a Fellow, and proceeded to Queen's College in October, 1875. He has been a prizeman of the college for mathematics. Mr. Pearson was educated at University College School, and also under private tuition with the Rev. L. Hensley, of Hitchin. He gained an open scholarship at King's College in 1875, and has been each year college prizeman in mathematics.

A REPORT just published by the Swiss Statistical Board gives some information as to the state of primary instruction in the various cantons of Switzerland. Out of 21,875 recruits examined during the year 1877, 11·7 per cent. proved to have primary instruction quite insufficient, and were sent back to the primary military schools. The better educated cantons are those in which manufactures are more developed, namely, Basel (town), Geneva, and Zurich, Schaffhausen and Thurgau. The worst educated are those of Appenzell (land), Uri, Wallis, and Freiburg (Catholic). Primary education seems to have become worse during recent years, as the results for 1877 are far below those of 1876.

SCIENTIFIC SERIALS

Journal of the Franklin Institute, December, 1878.—From experiments here described by Mr. Jacques, it appears that currents of air of varying density, as in Tyndall's well-known experiment, not only diminish the *intensity* of a sound, but affect its *distinctness*. This holds good especially for the human voice, and for musical instruments with few overtones (as the flute). The effect on the voice is that of a repetition of each syllable several times in close succession. Sound-waves were traced out in the space of an auditorium in Boston, and their confusion shown on introducing air-currents. The good acoustic properties of the Baltimore Academy of Music are proved to be due to arrangements by which a large volume of air is conducted, in gentle current, across the stage and diagonally towards the roof. When, by closing certain valves, ventilation was arrested and currents of circulation generated, the sound was noticed to be "dead," or "confused and indistinct."—Dr. Dudley investigates the chemical composition and physical properties of steel rails, deducing some rules for guidance of the Pennsylvania Railroad Company.—Mr. Dupuy writes on the direct process of making wrought iron and steel,—Mr. Dumont on tests of boiler iron,—and Prof. Haupt on the use of the heliotrope in geodetic surveys.

THE *Archives des Sciences physiques et naturelles* (parts 251 and 252, November and December) contain the following papers of interest:—On ytterbina, a new earth contained in gadolinite, by C. Marignac.—On a transformation of dibromethylene into an acetone with four atoms of carbon, brought about by the action of hypobromous acid, by E. Demole.—A note on Dr. Heine's work on the formation of mountains, by E. Renevier.—On the geography and archæology of forests, by Dr. Asa Gray.—Recent researches in solar chemistry, by J. Norman Lockyer.—Observation of a case of migration of carps, by A. Bartholoni.—On a general method of continuous integration of any numeric function, applied to several theorems furnished by the mathematical analysis of the calculation of the curves of a new thermograph, by Raoul Pictet and Gustave Cellérier.—On the limnograph of Secheron, near Geneva, by Ph. Plantamour.—A note on the useful effect of magneto-electric machines and the production of electric light, by A. Achard.—On the reappearance of Encke's comet of short period, with a history of this comet, by Alfred Gautier.—Some remarks on the migration of carps by G. Lunel.—On the ophite of Spain, by M. Calderon.

Bulletin de l'Académie Royale de Belgique, Nos. 9 and 10, 1878.—This contains an account, by M. Dupont, of a recent important "find" of fossils in the Sainte Barbe, one of the coal mines of Bernissart (a village near the French frontier), consisting of five skeletons of large adult iguanodons together with tortoises, numerous fishes, and plant-impressions, constituting a fauna and flora wholly new for the country. The bones are unfortunately impregnated with pyrites, so that they are readily disaggregated on contact with air, but they have been carefully removed in plaster to Brussels, after precise noting of position, &c. The fossils were found at several different levels separated by layers of sterile clay. There is no indication of molluscs of any kind. The deposit is thought to be of the Wealdian horizon, and is remarkable, both in itself, and in its relations to the subterranean orography of the valley of Mons, and the lower cretaceous strata of Hainaut.—M. Plateau writes on a law of the persistence of impressions in the eye. With two disc having the same number of sectors, and the white sectors of the one being equal in angular width to the black discs of the other, the "times of apparent constancy," of the two impressions are to each other in inverse ratio of the brightnesses of the two grey tints producing these impressions. A complete impression, whether intense or weak, has no appreciable time of apparent constancy; and the time is longer, the more incomplete the impression. The degree of illumination of the object has but a weak and indirect influence on the time of apparent constancy.—M. Longchamps contributes further additions to the synopsis of the Gomphines; and M. Renard lithological researches on the phtanites of the carboniferous limestone of Belgium.—M. Montigny describes an experimental arrangement for the study of coloured stars.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, December 19, 1878.—"On the Torsional Strain which remains in a Glass Fibre after Release from Twisting Stress," by J. Hopkinson, D.Sc., F.R.S.

It has long been known that if a wire of metal or fibre of glass be for a time twisted, and be then released, it will not at once return to its initial position, but will exhibit a gradually decreasing torsion in the direction of the impressed twist. The best method of approximating to an expression of the facts has been given by Boltzmann ("Akad. der Wissensch. zu Wien," 1874). He rests his theory upon the assumption that a stress acting for a short time will leave after it has ceased a strain which decreases in amount as time elapses, and that the principle of superposition is applicable to these strains, that is to say, that we may add the after-effects of stresses, whether simultaneous or successive. Boltzmann also finds that, if $\phi(t)\tau$ be the strain at time t resulting from a twist lasting a very short time τ, at time $t = 0$, $\phi(t) = \frac{A}{t}$, where A is constant for moderate values of t, but decreases when t is very large or very small.

The glass fibre I examined was about twenty inches in length. The glass from which it was drawn was composed of silica, soda, and lime; in fact, was glass No. 1 of my paper on "Residual Change of the Leyden Jar" (*Phil. Trans.*, 1877). In all cases the twist given was one complete revolution. The deflection at any time was determined by the position on a scale of the image of a wire before a lamp, formed by reflection from a light concave mirror, as in Sir W. Thomson's galvanometers and quadrant electrometer.

The first point to be ascertained from the results was whether or not the principle of superposition, assumed by Boltzmann, holds for torsions of the magnitude used.

The experiments indicate a large deviation from the principle of superposition, the actual effect being *less* than the sum of the separate effects of the periods of stress into which the actual period may be broken up.

They also appear to indicate the form $\phi(t) = \frac{A}{t^{\alpha}}$, α being less than, but near to, unity. If $\alpha = 0{\cdot}95$ we have a fairly satisfactory formula for the case in which the fibre was twisted two hours.

In the author's paper on "Residual Change of the Leyden Jar" that subject is discussed in the same manner as Boltzmann discusses the after-effect of torsion on a fibre, and it is worth remarking that those results can be roughly expressed by a formula in which $\phi(t) = \frac{A}{t^{\alpha}}$. For glass No. 5 (soft crown) $\alpha = 0{\cdot}65$, whilst for No. 7 (light flint) it is greater: but in the electrical experiment no sign of a definite deviation from the law of superposition was detected.

January 16.—"On the Effect of Strong Induction-Currents upon the Structure of the Spinal Cord," by William Miller Ord, M.D.